Using Network Neuroscience to Study Flow Experiences During Media Use

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What is Flow?

Csikszentmihalyi's Theory of Flow[1]

- When (a) task goals are clear, (b) feedback is immediate, and (c) there is a balance between the task difficulty and an individual's ability at the task:
  - High attentional demand
  - Diminished self-consciousness
  - Loss of temporal awareness
  - Perception that task is not physically/mentally taxing
  - High levels of intrinsic reward such that the task is perceived as intrinsically motivating
- Together, these outcomes describe *flow* experiences

[1] Csikszentmihalyi. (1975)

Things We Know

Empirical evidence shows that flow:

- Is an outcome of media use[2]
- Modulates subsequent media effects[3]
- Is positively related with intentions for media use[4]

We also know that:

- Some individuals are more likely to experience flow than others[5]
- Flow proneness has distinct neurobiological mechanisms[6]
- Flow proneness is heritable[7]

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[2] Keller & Bless. *Personal. Soc. Psychol. Bull.* (2008)

[3] Matthews. *Comput. Human Behav.* (2015)

[4] Liu, Liao, & Pratt. *Comput. Educ.* (2009)

[5] Ullén, et al. *Pers. Individ. Dif.* (2012)

[6] de Manzano, et al. *Neuroimage* (2013)

[7] Mosing, et al. *Pers. Individ. Dif.* (2012)

But What About Content?

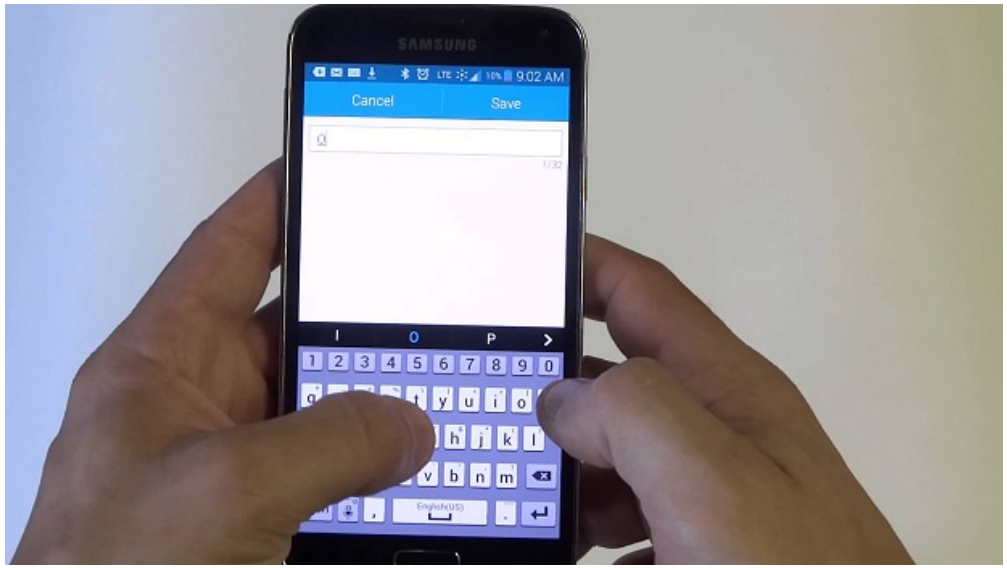
Dynamic changes in media *content* are theorized to contribute to flow[8]

[8] Sherry. *Commun. Theory* (2004)

Inadequet Measurement Tools

It is impossible to understand how content dynamics contribute to flow using existing measurement tools.

Survey Instrument



Experience Sampling Method

A Neural Conceptualization of Flow

"Flow is a discrete, energetically optimized, and gratifying experience resulting from the synchronization of [cognitive control] and reward networks under condition of balance between challenge and skill" [9]

- H1: Flow experiences result in a network synchronization process between cognitive control and reward networks
- H2: This network synchronization is a discrete state that is separable from other neuropsychological states
- H3: This network synchronization process corresponds to an energetically efficient brain state
- H4: This network synchronization manifests as an enjoyable experience

[9] Weber, et al. *Commun. Theory* (2009)

How to Bridge this Gap?

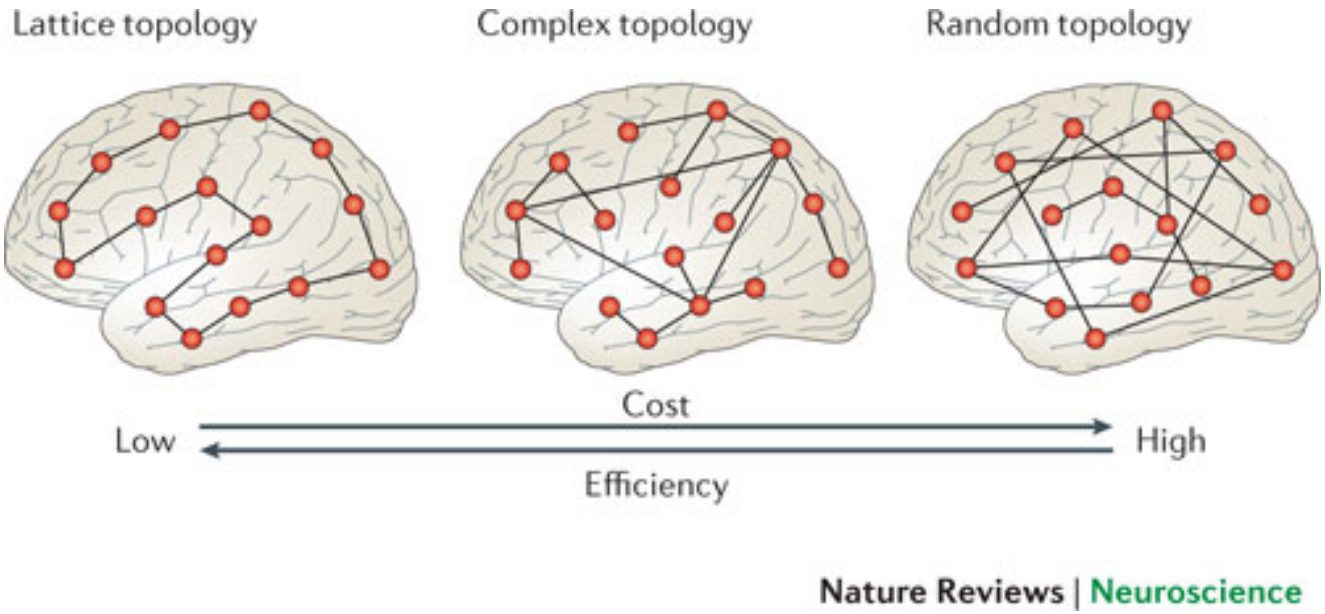
A multi-phase research agenda:

- Test the basic premises of Sync Theory (H1 & H4 supported)[10]
- Identify potential neuromarkers of flow (H1 & H3 supported; today's talk)[11]
- Are these neuromarkers dynamic or static? (H2 test; data collection ongoing)
- Can we link dynamic changes in these neuromarkers to media *content*? (in planning)

[10] Huskey, et al. *Cogn. Affect. Behav. Neurosci.* (under review)

[11] Huskey, et al. *J. Commun.* (under review)

Characteristics of Networked Brains

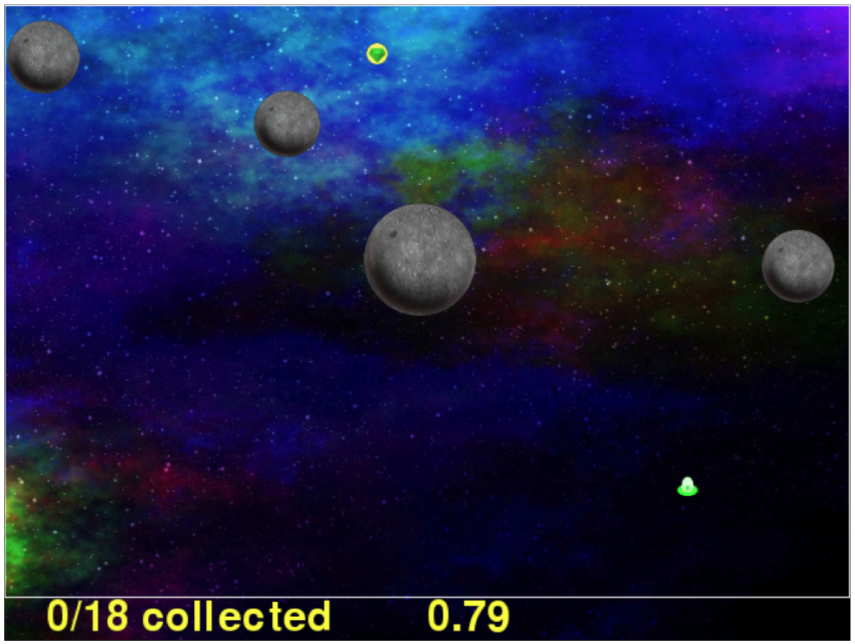


Brain networks have different energetic costs[12]

- Low cost/efficiency (left): Nodes connected to nearest neighbor
- High cost/efficiency (right): Random network
- Medium cost/efficiency (middle): Many human brain networks

[12] Bullmore & Sporns Nat. Rev. Neurosci. (2012)

Stimulus



Three Conditions:

- Low-Difficulty (Boredom)
- Balanced-Difficulty (Flow)
- High-Difficulty (Overload)

Asteroid Impact:

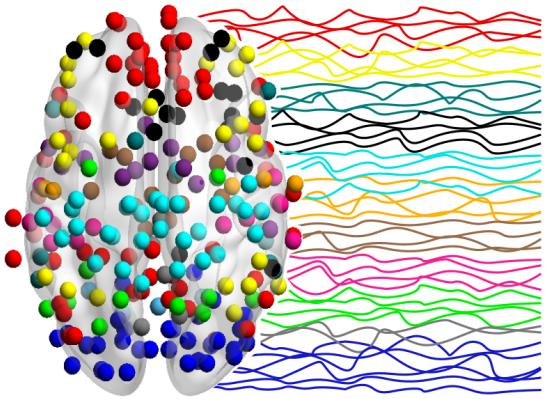
- An open-source video game
- High experimental control
- Custom content analysis
- Naturalistic task
- Download and contribute `https://github.com/richardhuskey/asteroid_impact`

Data Etraction & Analysis

A

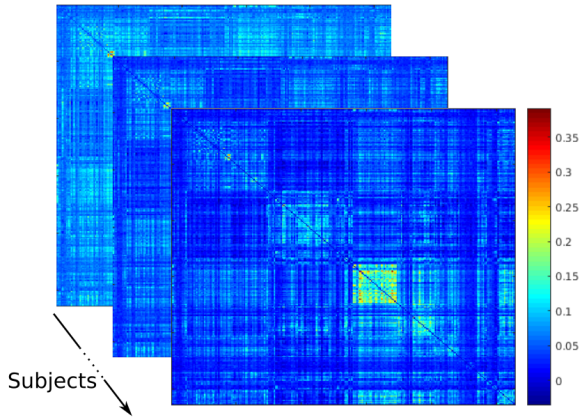
Extract timeseries from nodes in Power et al. (2011) atlas

- Sensory/Hand
- Sensory/Mouth
- Cingulo-Opercular
- Auditory
- Default Mode
- Memory
- Visual
- Fronto-Parietal
- Salience
- Subcortical
- Ventral Attention
- Dorsal Attention
- Cerebellar
- Uncertain



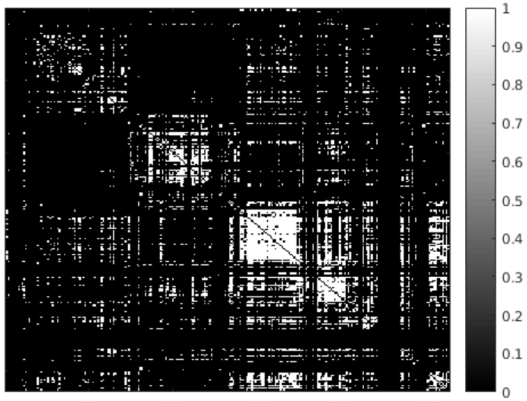
B

264x264 correlation matrix



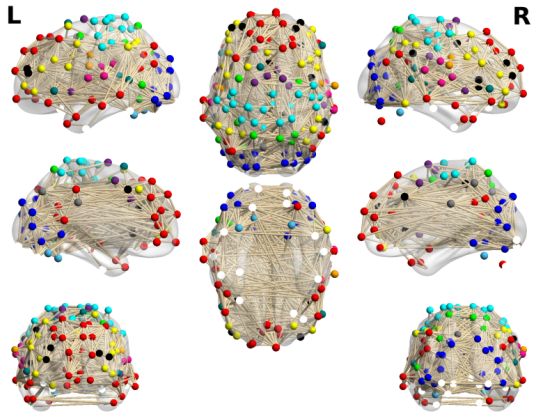
C

Threshold & binarize group-level matrix



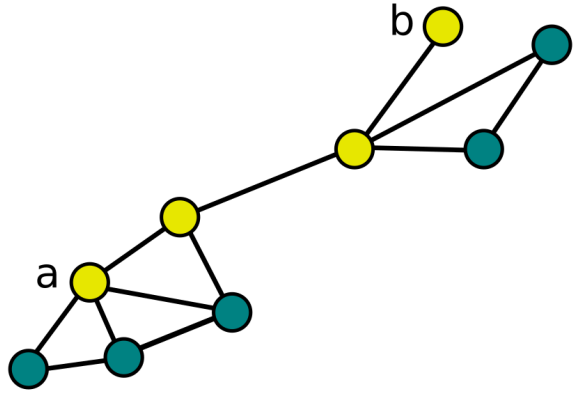
D

Sparse graph

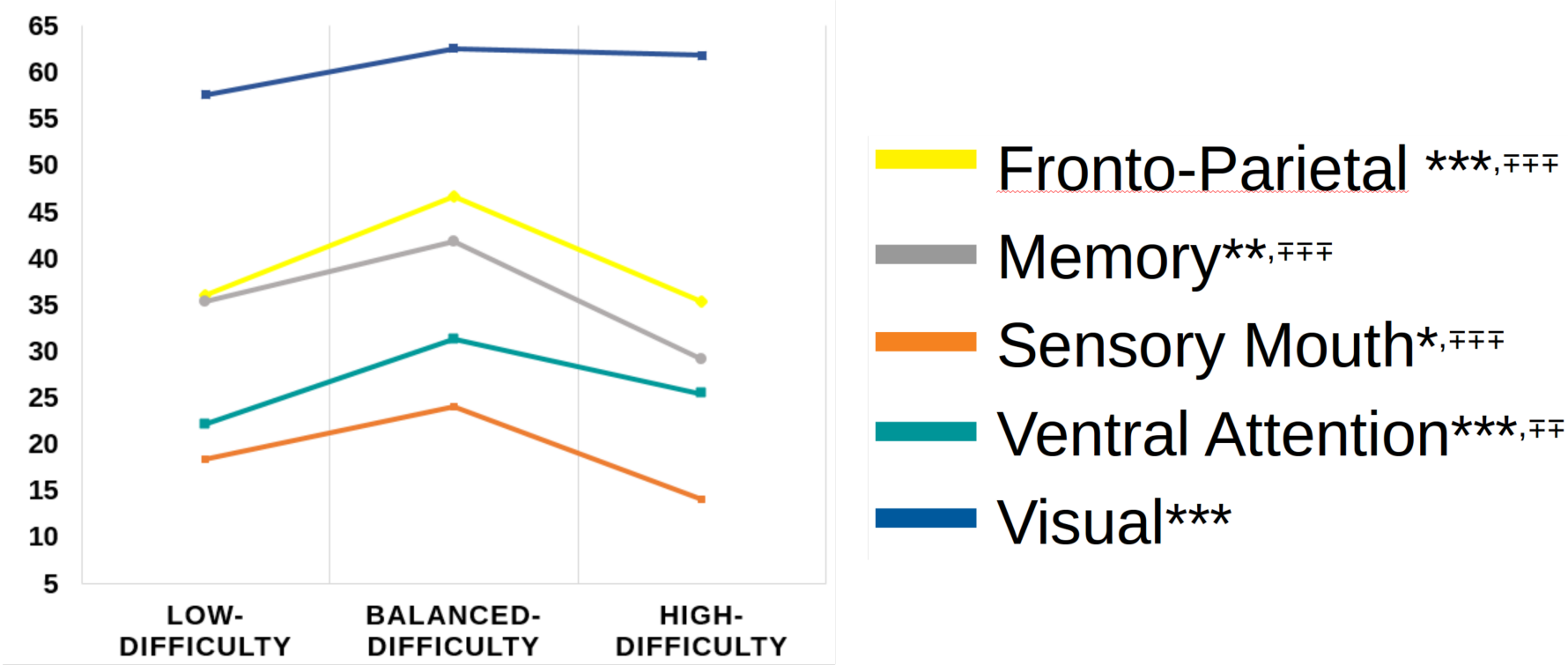


E

Graph metrics: degree & global efficiency



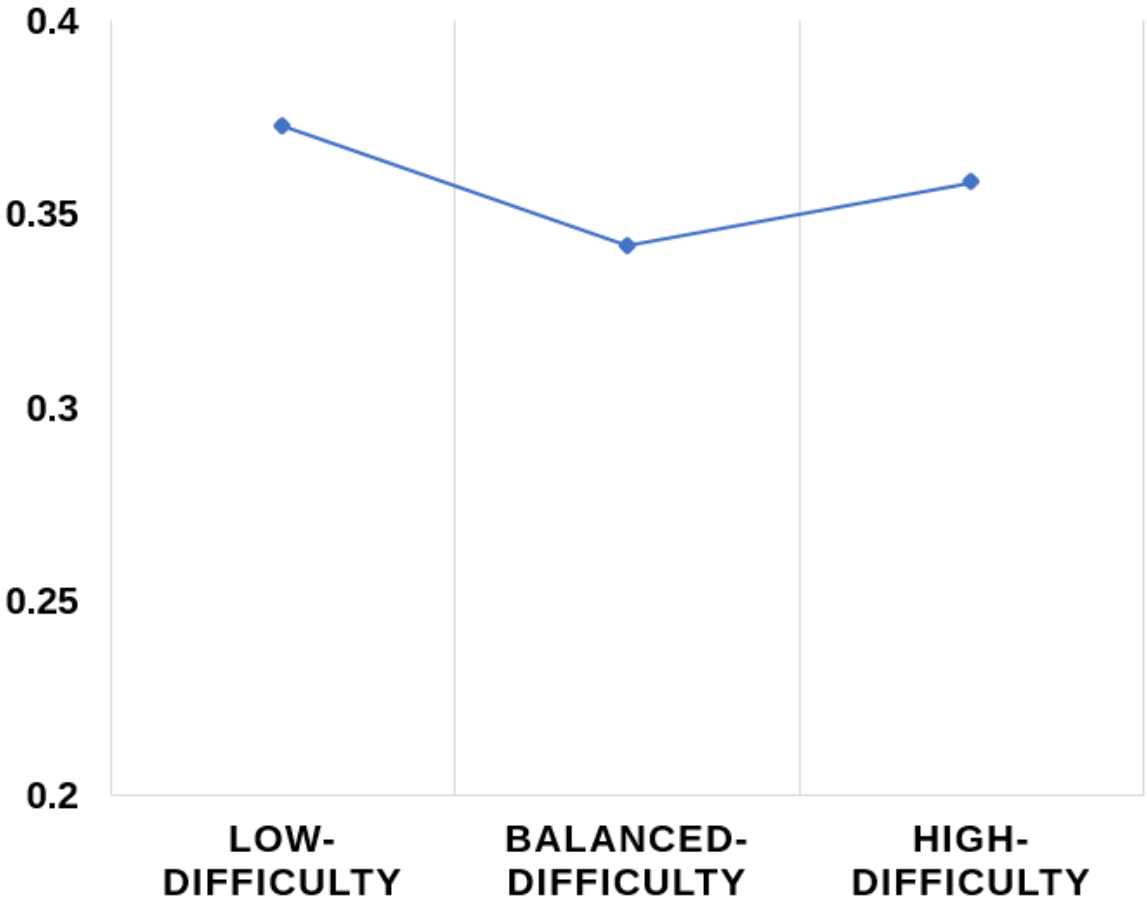
Degree Results



Balanced-difficulty > low-difficulty (FDR corrected):
*q < .05, **q < .01, ***q < .001

Balanced-difficulty > high-difficulty (FDR corrected):
∓∓q < .01, ∓∓∓q < .001

Global Efficiency Results



Balanced-difficulty $>$ low-difficulty ($t = -19.12, p < 0.001$)
Balanced-difficulty $>$ high-difficulty ($t = -10.03, p < 0.001$)

What Have We Learned?

This study:

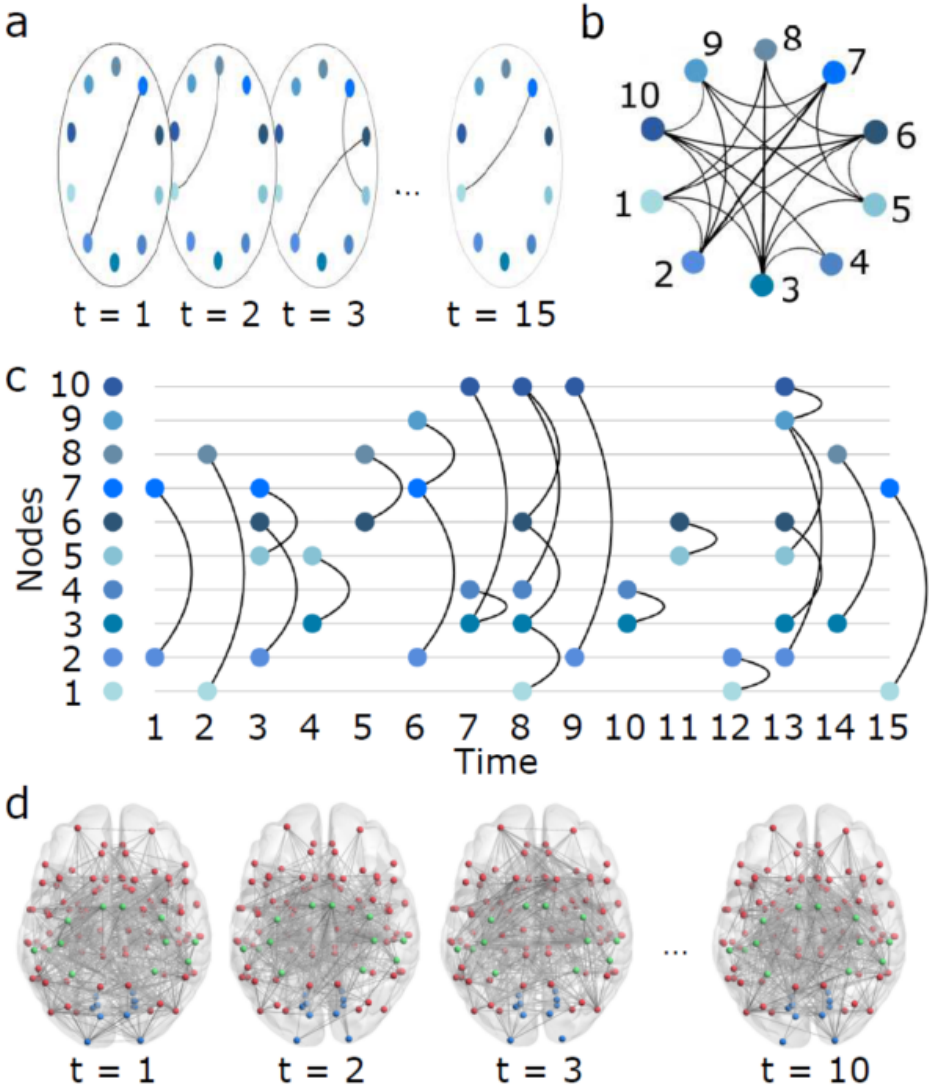
- Replicates previous work supporting H1
- Provides the first evidence supporting H3
- Suggests potential neuromarkers of flow

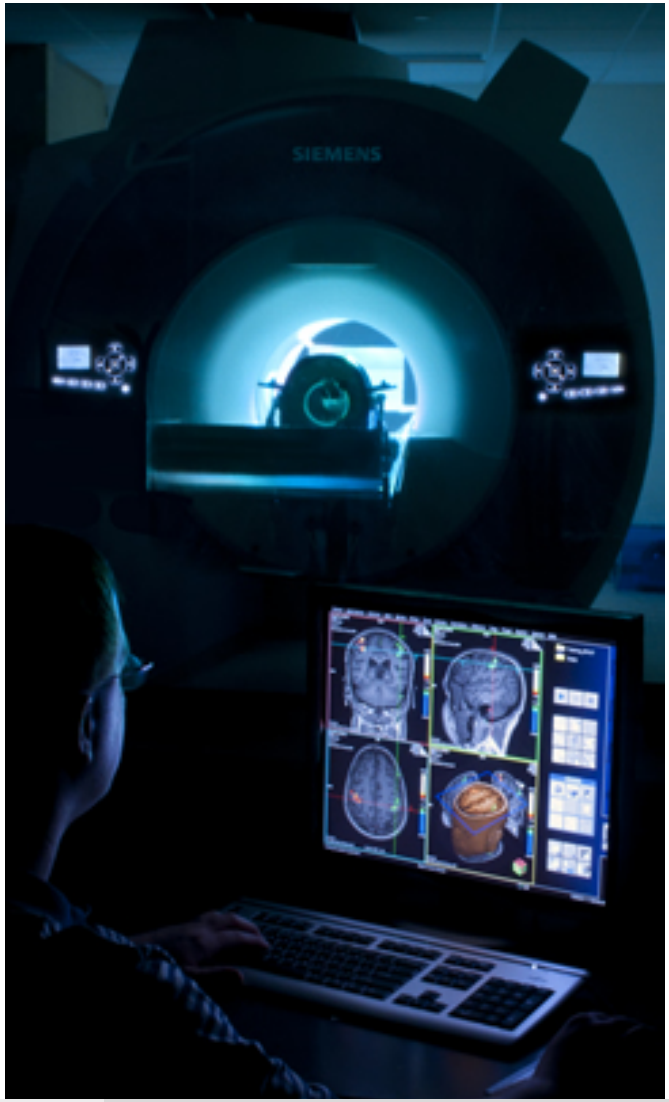
And paves the way for:

- Replication work
- Evaluating if these neuromarkers are dynamic or static (H2 test; data collection ongoing)
- Linking dynamic changes in these neuromarkers to media *content*? (in planning)

In Data Collection

A better test of H2 (Dynamic Network Hypothesis)





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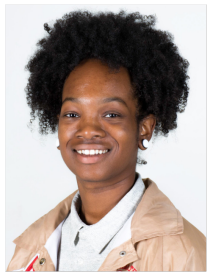

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Our lab: `http://cogcommscience.com/`
Our data & code (OSF): `https://goo.gl/DGufcE`
Our stimulus (GitHub): `https://goo.gl/Ge7NLF`